gree of local pain and tenderness. Ascent of the process extends the area of pain. Variable degrees of sympathetic overactivity may augment and diffuse the pain. These basic mechanisms may develop in a dramatic and extreme form to produce the symptoms of phlegmasia cerulae dolens, a suddenly developing, galloping phlebitis involving more or less simultaneously the entire venous tree of an extremity. The coincident arterial as well as venous vasoconstriction contributes to the development of swelling, tension, cyanosis and inordinate pain in the extremity. Opiates only partially relieve the pain. Sympathetic blocks and local heat do little more. Occasionally, massive irreversible gangrene develops.

Therapy for any of the variations of deep thrombophlebitis is dictated by its manifestations. Anticoagulants, unless contraindicated, are of value in arresting the spread of intravascular thrombosis. In the relatively painless form, little more is needed. These drugs should be continued until local tenderness has completely subsided. As with any other inflammatory processes, elevation, rest and local heat reduce the pain of the more inflammatory forms. Sympathetic blocks or sympathectomy, even in the presence of vasoconstriction, have been generally ineffective in the treatment of deep thrombophlebitis.

CHRONIC VENOUS STASIS

The pain of chronic venous stasis appears with varicose veins and as a residual effect of deep thrombophlebitis.

In both syndromes valvular incompetence interferes with the normal mechanism for returning venous blood from the lower extremities. Increased dependent venous pressure results, producing chronic aching fatigue in the lower legs after prolonged dependency.

Walking tends to decrease venous pressure and accordingly eases the discomfort. Elastic support to the level of the knees, if adequate to prevent edema, usually gives satisfactory relief. This requires the use of heavy, tight elastic stockings worn during the hours when the patient is erect. Painful night cramps in the calf and thigh muscles are frequent complaints of patients with either varicose veins or chronic phlebitis. The cause is obscure.

Surgical resection of varicose veins by removing the valveless portion of the venous system is the preferred alternative to elastic compression for patients with primary varicosities. Various surgical procedures have been attempted for the treatment of postphlebitic syndrome—that is, popliteal or superficial femoral vein ligation. The early enthusiasm for such procedures, however, has largely disappeared.

Pain as Observed by the Orthopedic Surgeon

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THE MAJORITY OF PATIENTS with painful conditions who are observed by an orthopedic surgeon describe their pain as deep and aching. Occasionally they will report that it has a burning, throbbing or pulling quality. Usually it is poorly localized. This may be explained, in part, by its tendency to spread. In the case of a shoulder lesion, for example, the patient will say that the ache tends to spread down his arm or into his neck.

Particularly troublesome in this respect, of course, is backache, with its familiar radiation of pain across the buttocks and down the posterior aspect of the thigh. Medical literature indicates that backache has been with us for a long time. In the period from about 1890 to 1910, this was known as sciatic scoliosis. When I was in school, the sacroiliac joint was incriminated, and, in the following decade, the herniated intervertebral disc was enthusiastically espoused as the chief cause of back pain with radiation into the extremities. We are perhaps now over the peak of this latter enthusiasm.

Several dissenting voices, however, have been raised from time to time. Arthur Steindler, for example, with reference to the disc concept, pointed out that pain which radiates from the low back tends to be continuous from this area, appearing in the buttocks, then gradually creeping down the posterior aspect of the leg. Isn't it odd, he said, if pressure on the fifth lumbar root is producing discomfort, that the pain should appear in the back and involve the area of the third sacral nerve, go down to the second and then to the first sacral and finally to the fifth lumbar nerve. Why should the pain not appear first in the foot, which is the area of the fifth dermatome?

Physicians and surgeons have always been interested in the distribution of pain as an aid to diagnosis, and since the earliest times investigators have attempted to find a rational basis for the distribution of pain associated with a particular disease or disorder. To understand better the peripheral patterns of distribution of the dorsal roots (segmental patterns), maps of dermatomes have been constructed to represent the cutaneous areas supplied by these nerve roots. Similarly, there have been attempts to plot maps of myotomes and sclerotomes, showing the distribution of the dorsal afferent nerve fibers to muscle and bone.

The person who consults these maps is likely to

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find them more confusing than helpful unless he takes into consideration the methods that were used in constructing them. Perhaps best known among the maps of dermatomes are those of Sherrington,[8] Bolk,[1] Head and Campbell,[4] and Foerster[3] and, more recently, Keegan and Garrett.[6] Sherrington, the earliest of these investigators, cut the dorsal roots above and below a given root in monkeys *(Macacus rhesus)* and mapped the response to skin pinching in the area of residual sensation. Although the spine and nerve roots of *Macacus* are very similar to those of man, there is in the lower extremities some question of analogous nerve roots and analogous areas of conformation. These maps, therefore, are a measure of minimal reflex response to a pinch in an animal of subhuman nervous development.

Bolk derived his descriptions of the dermatomes from the gross anatomical dissection of one human body. As one would expect, the areas derived by this method are smaller and show less overlap than the areas obtained by other methods, owing to the difficulty of dissecting out the finer nerves to the skin.

Head based his maps largely upon the distributions of lesions of herpes zoster. It has been conjectured that these lesions result from antidromic stimulation of fibers in the dorsal roots, and the areas thus outlined do not seem to reflect the complete areas of segmental innervation.

Foerster, whose descriptions of dermatomes are perhaps the most widely accepted, cut the dorsal roots in human subjects and then plotted the remaining sensory field. The data of his maps were presumably derived by neurological testing, which usually involves a sensory judgment and verbal response on the part of the patient. Foerster found less overlap in the segmental areas for pain than in those for touch.

Despite the disparities among these earlier maps, several general conclusions can be drawn from them. Clearly, there is a considerable overlap of contiguous skin segments. Also, it is generally agreed that the interruption of a single posterior root does not give rise to an area of anesthesia. Thus, if the boundaries of a segment are determined by cutting several dorsal roots and charting the areas of remaining sensibility—the method of "isolation"—the segmental areas that result are considerably greater than those obtained by cutting single roots and trying to map the area of slightly altered sensibility that will result. Dermatomes plotted on the basis of tactual stimulation show more overlap than those plotted in response to noxious stimulation.

In the 1930's, the observation that a herniated intervertebral disc gave rise to pain of segmental distribution appeared to offer a new method of mapping the peripheral distribution of the dorsal root nerves in human subjects. The further observation that areas of skin are hypoalgetic in subjects with disc pain led Keegan to draw up a new map of the dermatomes on the basis of these areas. Keegan's maps varied distinctly from the earlier maps of the dermatomes in that in his the dermatomes extended as continuous bands from the spine into the limb. This conception of the dermatomes contradicts the commonly accepted theory of the loop development of the dermatomes of the limb, in which the outermost segments have lost their relation to the trunk. The earlier charts of Sherrington and Foerster were based on sensory mapping, following the resection of spinal roots, whereas Keegan's maps reflect decreased sensitivity in skin areas associated with an abnormal condition of the spinal root, and the presence of severe pain in the deep tissues.

The presence of areas of hypoalgetic skin in association with pain in the deep tissues is not an unusual observation. In the author's studies on the distribution of pain in the deeper tissues, a decreased sensitivity of the skin in concentric areas about the site of deep pain was demonstrated. The significance of these areas of hypoalgesia is still largely a matter for speculation.

The disparity between the distribution of pain accompanying a herniated intervertebral disc and the distribution of pain to be expected from classic dermatome mapping is perhaps not too surprising for at least two reasons: (1) As just discussed, the distribution in the case of the disc is complicated by an underlying condition of severe pain, whereas no such pain was a condition in the determination of the classic dermatome. (2) Furthermore, the pain in the case of the disc is localized in the deeper tissues, and there is reason to believe that the deeper segments are extended into the extremities quite differently than are the skin segments.

In 1940 at the University of California we became interested in the irritation of the deeper tissues and their innervation. A little earlier, Kellgren,[7] working in the laboratory of Sir Thomas Lewis, had stimulated the deeper tissues by means of salt solution and had shown that the resulting pain did not remain localized in the area of the injection but tended to radiate. In 1944, a colleague and I published some work[5] on the sensitivity of connective tissues, using salt solution and pressures. We found that from all the connective tissues of the body so tested pain could be evoked. The most surprising thing, however, was that when we produced a painful experimental lesion, the pain did not remain localized but tended to spread. Occasionally, this aching pain which was initiated by a very small irritative lesion spread for a considerable distance. Later, in the same laboratory Feinstein[2] and coworkers attempted to chart experimentally the seg-

mental pattern of deep spreading pain. Paravertebral injections of 6 per cent saline solution were made in human subjects at each intervertebral level from the occiput to the sacrum. The distribution of pain resulting from these injections was found to approximate a segmental plan. When compared with the conventional dermatomes, however, the patterns of distribution of the diffuse pain in the deep tissues was found to overlap considerably more with adjacent segments. The chief disparities in this regard were found in the segments extending into the extremities, since, in most instances, the pain radiated from the site of the injection and each segment maintained a relation with the trunk. Embryologically, in the development of the limb buds, the skin segments that are drawn most distally lose their relation with the trunk, with the formation of dorsal and ventral axial lines; whereas, the deeper tissues that are innervated by the corresponding spinal nerves would appear to be drawn out in continuous bands from the trunk.

The important point to be made from all this is that the configurations of the dermatomes cannot be taken to represent accurately the segmental relations of the underlying muscle and bone. It is apparent that we still have much to learn concerning the segmental innervation of the deep tissues before we can properly understand the patterns of pain to be observed experimentally or in pathological conditions.

What, then, can be said at the present time by an orthopedist concerning the pain of the deep tissues? I think that present experimental and clinical findings afford the following useful generalizations: Pain can be elicited from the deep structures of the body, particularly the connective tissue structures. The stimulus required may not be severe or extensive. Pain so aroused always tends to radiate either proximally or distally from the point of stimulation. The pain is characteristically deep, aching, heavy in type, and is often described as having a three-dimensional character. It is not referred to the surface of the body but is reported as remaining within the deep tissues. If the radiation of pain is intense, the skin overlying the area of pain may become slightly hypoalgesic. The deep tissues within the area of maximal radiation may become tender to pressure. Neurological findings indicative of nerve compression, such as muscular weakness, reflex changes or alterations in proprioception, may complicate the picture but are not an essential part of this deep pain.

Finally, it should be emphasized that the presence of pain which tends to radiate does not necessarily indicate direct irritation or compression of a peripheral nerve or of a spinal nerve root. The characteristic, radiating pain that I have discussed is to be expected in any irritative lesion involving the deeper tissues. Failure to appreciate this phenomenon is likely to lead one astray in the diagnosis of painful lesions of deep origin. This is particularly true in cases diagnosed as sciatica. In the present enthusiasm for herniated intervertebral discs, it may be overlooked that irritation of the deeper tissues will produce radiating pain without direct involvement of a spinal root.

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Neuralgia and Other Pain As Observed by the Neurologist

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PAIN HAS SPECIAL PECULIARITIES and it is distinguished from other sensations, like those of position, touch, and even temperature, by its emotional character which it shares only with the sensation of sexual excitement. As a matter of fact, these two sensations have so much in common that they sometimes may change from one to the other.

Another peculiarity which these two types of sensation have in common is their dependence upon physiological summation. Achelis[1] showed that a single stimulus to a pain fiber almost never will produce the sensation of pain, but that repeated stimuli are necessary. It is interesting that summation can be produced both by repeated stimulation of the same point or by spatial summation, as for in-

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